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NATIONAL RESEARCH INITIATIVE COMPETITIVE GRANTS PROGRAM

United States Department of Agriculture

Cooperative State Research, Education, and Extension Service

August 1999

Genetics Is Key to Trees' 'Leafing' – and 'Leaving'

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How does a tree "know" when to grow and when to become dormant? This process is a critical one. The tree must have the longest possible growing season – to produce the maximum amount of wood for lumber, paper, and fuel – but it also must become dormant in time to prevent frost damage to growing leaves and shoots.

Trees adapt genetically to the length of the growing season in their local environment. This is easily demonstrated by collecting seeds of a tree species found at different latitudes and planting the seeds in one place, known as a "common garden." This ensures that all the trees will experience the same environment, and any differences in dormancy will be due to genetics.

In common gardens, researchers find that seeds collected from northern latitudes produce trees that begin growing early in the spring, stop growing early in the autumn, and remain dormant for a long time during the year. Seeds from southern trees will grow much of the year and have only a short dormant period. Because of this genetic adaptation, attempting to grow trees in the wrong environment creates problems.

Although researchers know that the timing of dormancy is under strong genetic control, they know very little about the number of genes involved in dormancy, or their identity.

Toby Bradshaw

Hybrid poplar clones demonstrate genetic differences in the timing of leaf emergence in spring. Each row of trees is a single clone (genetically identical to each other). Leaves have emerged on the clone in the left row, but not on three clones in the other rows.

Cottonwood Trials

USDA's National Research Initiative (NRI) Competitive Grants Program is supporting basic research at the University of Washington, Oregon State University, and The Ohio State University to understand the genetic control of dormancy, *Trees genetically adapt to the length of the growing season in their local environment.*

using a combination of physiological and genetic methods. Researchers use hybrid cottonwoods for their experiments because they are fast growing (10-15 feet in height each year) and easy to breed.

To produce cottonwood hybrids that are highly variable for dormancy timing, researchers crossed a male Eastern cottonwood (*Populus deltoides*) from Texas (30° N latitude) with a female black cottonwood (*Populus trichocarpa*) from Washington State (48° N latitude), then crossed two of their hybrid offspring to give them 350 different seedlings to plant in common gardens at Corvallis, OR, and St. Paul, MN.

Trees growing in the common gardens were observed periodically, and the dates of bud formation in autumn and bud opening in spring were recorded.

Genetic Mapping

Researchers used the cottonwood trials to develop a genetic map of all the chromosomes in cottonwood. They located 10 regions (called "QTLs") on the chromosomes that affected dormancy timing, demonstrating that this trait is more genetically complex than other characteristics such as disease resistance.

The final experiment was to genetically map five genes that physiologists predicted would be involved in dormancy timing. Two of these genes encode light-sensing phytochromes (pigment-protein complexes found in all plants), which are believed to help the tree determine the time of year by measuring the length of daylight.

The other three genes of interest were mapped for *Arabidopsis thaliana*, a small mustard plant used widely by plant scientists as a model for genetic studies. As an annual plant, it never becomes dormant, but its seeds have a genetic mechanism for remaining dormant until conditions are right for germination.

Remarkably, researchers found that two of the "candidate" genes, a gene that encodes phytochrome B2 and the *Arabidopsis* seed dormancy gene ABI1, map to the same position on the cottonwood chromosomes as two of the QTLs affecting dormancy timing. Given this result, it seems possible that the genes controlling a complex trait in a forest tree have now been identified, although verification experiments in transgenic (genetically engineered) trees are still required.

Impact

Rapid advances in plant genetics have allowed researchers to identify individual genes that may be responsible for controlling dormancy and growth in trees. Once these "dormancy genes" are cloned, they can be used to breed or genetically engineer trees for maximum wood production in any climate.

The research reported in this factsheet was sponsored by the Plant Genome Program of the Plants Division of the National Research Initiative Competitive Grants Program. To be placed on the mailing list for this publication or to receive additional information, please contact the NRI (202/401-5022 or NRICGP@reeusda.gov). The factsheet also is accessible via the NRI section of the Cooperative State Research, Education, and Extension Service website (http://www.reeusda.gov/nri).